He was also a member of the American Society of Civil Engineers; of the Rensselaer Society of Engineers, and of the Engineers' Club of Philadelphia, of which he was a Past President.

In 1892 he delivered a course of lectures on railroads at the Rensselaer Polytechnic Institute, in which he conducted the students through the actual surveys and calculations of the work.

In 1880 he published a work on *Railroad Engineers' Practice*, which has gone through several editions.

Mr. Cleeman was a thoroughly experienced engineer, cautious, intelligent and original in his analysis of theoretical problems, as well as in the execution of engineering work. He was careful to first ascertain that any work he undertook was theoretically correct before carrying it out. His grasp of theoretical subjects was so great that it enabled him to choose wise proximate methods. A friendly critic, he was also a keen one, and his views were generally correct. He did not hesitate to express his opinion on all subjects pertaining to his profession, but never insisted on the acceptance of his view by others; nor had he any of that selfish push and conceited manner which so often meets with undeserved success. A refined, cultured, courtly gentleman, he was entirely unselfish, modest and retiring. His first thought was always of others, never of himself. He was the light of a large circle of friends, as well as of his family.

His death has caused a heartfelt sorrow and sense of loss, not only in the family circle where his sweet nature and gentle manners will always be missed, but amongst the large number of warm and sincere friends, who also loved and honored him

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The Dynamics of Boxing.

By R. Meade Bache.

(Read before the American Philosophical Society, May 4, 1894.)

The fact that a certain statement lately appearing in the daily press obtained circulation proves how great the general ignorance of some simple physical laws still is. This statement was to the effect that Sandow, "the strong man," is able to strike a blow of 3000 pounds, could break an arm with its impact, and intends to study boxing so as to defeat Corbett. A few observations, therefore, as to the fundamental laws connected with the subject of the possible degree of the deployment of muscular force by human beings in the act of striking a blow will not be out of place for

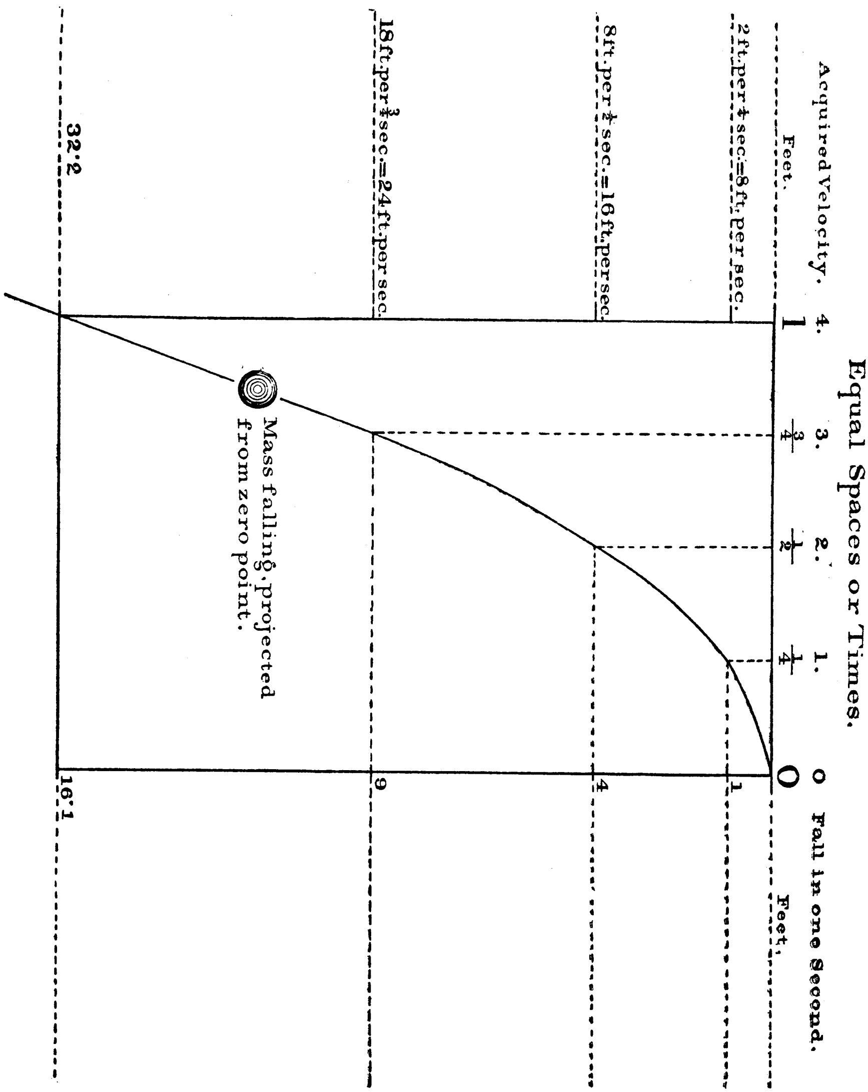
popular instruction. I do not, of course, presume to instruct members of this Society as to these laws, with which they are conversant, but the higher instruction is like head of water, whence the water flows to and filters through lower levels. Besides, beyond the mere restatement here of the laws to which I refer, lies matter with which I think that not even the majority of the members of this Society are conversant. These reasons form, in sum, my explanation for introducing this particular subject to the Society.

The momentum, as you are aware, with which a body, falling freely near the surface of the earth, strikes, varies with the latitude, or otherwise expressed, with the distance of a given place from the centre of the earth, which, owing to the configuration of the earth, corresponds with the latitude. But, for general purposes, and quite sufficiently precise for this, the distance, in the first second, which a free body falls, near the surface of the earth, from a state of rest, is accepted as 16.1 feet, and the velocity which it has acquired by the end of that space and at the termination of that time, as twice 16.1 feet, or 32.2 feet in that second.

The diagram on the blackboard illustrates clearly the effect upon a body moving for one second under the influence of gravity. To understand, then, what follows, it will only be necessary to observe, by referring to the diagram, that the successive spaces traveled by the falling mass represent the squares of intervals, whether of space or time, and also that, although the maximum space traversed in a first second of fall is only 16.1 feet, yet that, correspondingly with the smaller spaces and the inclusive one (all squares of space or time), the acquired velocity doubles continuously, being, instead of 16.1 feet, 32.2 feet in the second, by the time that it has reached the end of the first second of fall. The diagram fully exhibits the law of both relative spaces and relative times concerned in the phenomenon. If the first unit of horizontal space on the diagram, one-fourth, be taken as a unit of time, then its square will represent the value of the corresponding distance of fall. This is 1 foot, with acquired velocity of 8 feet. For successive units of time,—if a mass falls in 1 second, as it does, 16.1 feet, then in 2 seconds it falls 16.1 feet multiplied by 2 squared. It falls in 3 seconds 16.1 feet multiplied by 3 squared, and in 4 seconds 16.1 feet multiplied by 4 squared, and so forth.

Could a soap-bubble move with the velocity of the swiftest cannon-ball, it would injure nothing that it might strike, while the

seemingly almost spent cannon-ball has more than once shorn off human limbs as though they had presented no more obstacle than



thistle-down. Suppose now, that a man weighing 190 pounds (about the maximum weight effective in the ring) should fall, as a

body falling freely near the surface of the earth, for the distance of 16.1 feet. As the moving energy of his mass would be compounded of the mass multiplied by the velocity with which it travels, it would follow that the shock at the end of 16.1 feet (which would take place in a second) would possess the momentum represented by multiplying 190 pounds by 32.2, or 6118 pounds. One, therefore, perceives from the diagram that if, for a weight of 190 pounds, a momentum of only about twice 3000 pounds is generated by gravity in a second, with a velocity *twice as great as a boxer's blow* (as it would be, if the velocity of the boxer's blow at the rate of four feet in a quarter of a second be here correctly rated), it is already demonstrated that a man of 190 pounds could not strike a blow of 3000 pounds, unless he could put his whole weight into it, when, for 4 feet, at the rate indicated, it would be 190 pounds multiplied by 16, or 3040 pounds; and putting his whole weight into it is impossible. But it is worth while to pursue the subject a little further.

Remembering what has just been remarked as to the momentum generated by the fall of a mass of 190 pounds during the first second of time from a state of rest, we must now, in order to make safe comparisons between conditions that are only analogous, not identical, begin by recognizing formally the fact that a man cannot deliver a blow involving the conditions of delivery in a second, over a distance of 16.1 feet, and with an acquired velocity of 32.2 feet. The distance concerned, to say nothing of the other differences, precludes direct comparison between the rate of the man striking and the rate due to gravity. We must therefore institute the comparison and come to a conclusion indirectly. The longest distance over which a tall man can deliver his average blow is about 4 feet. A man with abnormally long reach, like the present boxer, Jackson's, can deliver it over 4.5 feet without changing his footing. If a man delivers it 4 feet in a quarter of a second (and this I think from observation the best boxer can do), he delivers it with the velocity with which gravity would have affected any mass in the first second of time from a state of rest, that is, with a velocity of 8 feet for the half second, or 16 feet per second.

If a boxer strikes four feet in a quarter of a second, of course he strikes at the rate of 8 feet in half a second, that is to say, he strikes with the same velocity as that due to acceleration from gravity during half a second. There is, however, in this case, no ques-

tion of acquired velocity, or what is otherwise known as acceleration, due to terrestrial gravity. I am merely putting the two equals, as derived from different sources of power, in juxtaposition, so as to compare and contrast them with each other, and thus to bring clearly before the mind that it is not likely that any boxer's blow can have a speed essentially greater than that represented by the acceleration due to gravity in half a second, or, in other words, the rate of 16 feet per second. Terrestrial gravity would, as indicated, have nothing to do with the force of the resultant blow. The blow being horizontal, the force of gravity with relation to it would be virtually *nil.* The statement here is limited strictly to the fact that if the boxer can strike 4 feet in a quarter of a second, he can strike that distance with the momentum that would be generated by gravity in one-half of a second, acting on any mass subjected to it from a state of rest.

The fact must be kept constantly in view that mass and velocity combined make momentum. With enormous weight and great slowness, the effect produced is not of the nature of a blow, but that of a push. With great velocity and minute weight, the blow produced is slight. With both great weight and great velocity, the blow becomes tremendous. Here it is well to add that the popular notion of the amount of his weight that a man can put into a push or a blow is highly erroneous. Mechanical engineers, who are continually obliged to make computations for the deployment of the force of pushing on capstan-bars for drawbridges and other places, know that, unless there are cleats on the ground from which the feet can obtain some purchase, from 15 to 20 pounds is about the proper amount to allow for the push of a man working under those conditions. The question therefore remains open in every individual case, unless instrumentally settled, as to what proportion of the mass of the boxer of 190 pounds enters into his blow, and this, with different men, varies as well as the speed. But supposing, for the sake of argument and demonstration, what has already been rejected, that the whole weight of the man enters into the blow, its momentum for 4 feet, at the rate indicated, would be represented by 190 pounds multiplied by 16, or the rate of speed, at the half-second point, due to the force of gravity for a first second, and would be, as already noted, 3040 pounds. A man cannot, however, as already stated, put his whole mass into a blow, because he cannot, by any muscular effort whatsoever, move freely in space. The indispen-

sable condition of his being able to deliver an effective blow is that he shall be, as to his feet, poised on the surface of the earth. So unless, by means of electrical recording apparatus, we determine the speed of a blow, and, by means of a dynamometer, determine the moving energy of it, and deduct one value from the other, we cannot ascertain how much of the effectiveness of a blow is owing to the weight of the human body thrown into it, and how much is derived from a speed which involves the whole person—hand, arm, and trunk.

It would follow, from all the evidence at my command, that if the speed of a blow of four feet be a quarter of a second, a man of even 190 pounds in weight cannot follow up, so as to make effective in his blow, with more than 32 pounds (in round numbers, a sixth of his weight) with velocity equal to free movement of fall of a mass for the first half-second, from a state of rest, above the surface of the earth. Barrett, the late well-known teacher of boxing in Philadelphia, a man of undoubted veracity, as highly esteemed in his day and limited sphere as was, at the beginning of this century, in a more extended one, Gentleman Jackson, of England, Byron's boxing master, once told me as remarkable that he knew a man who could strike 500 pounds. This meant, of course, as tested by a dynamometer. If then, in fine, the time of a boxer's blow be a quarter of a second, the length 4 feet (which would make, as already remarked, the rate the same as that due to the effect of gravity on a mass in the first half second, fallen from a state of rest), and the proportion of his weight accompanying it be 32 pounds, he would strike with the momentum represented by 32 pounds multiplied by 16, or 512 pounds. This momentum, if the reader experienced in boxing will consider the speed here ascribed to the blow of the finest boxer, and the confirmatory evidence derived from the statement of Barrett, would seem to be very near the mark. No one will be likely to maintain, after what has been said, the possibility of striking an effective blow of 4 feet in length in less than a quarter of a second; or that, of the weight of a man of 190 pounds, more than 32 of them can be put into a blow corresponding with the rate of 16 feet per second.

Up to the point we have reached the conclusions drawn were partly dependent upon an estimated velocity of blow, derived from observation, not experiment. But a friend having reminded me that, among Mr. Muybridge's series of photographs of movements of man and

the lower animals is one illustrating the speed of a blow, the examination of it which has followed has led to a remarkable confirmation of the preceding estimate of speed. Plate No. 333 of the Muybridge series represents the phases of a knockdown blow, including the effects, until the person struck is prone on his back on a mattress. The intervals between the photographic phases is ninety-six one-thousandths of a second. Three successive phase-pictures, thus virtually taken one-tenth of a second apart, represent the blow from start to finish. In the first, the striking arm is drawn back and starting from its point of departure. In the second, the arm is seen projecting about half way between the boxing opponents. In the third and last phase of the blow the fist of the striker lands on his opponent. The interval between the first and second phase having been virtually one-tenth of a second, and that between the second and third also one-tenth of a second, the blow was therefore delivered in virtually one-fifth of a second. Measurements on the pictures giving the successive phases show that the length of the blow from start to finish was 38 inches. Here we have the rate of 38 inches in one-fifth of a second. We have previously used the estimated rate of 48 inches in one-fourth of a second. The data derived, on the one hand, from observation, and that, on the other, from experiment, coincide within a small fraction—within half an inch.

It is open to observation that boxers who make their living by ring-fighting carefully conceal from the public, knowledge of the momentum with which they can strike, although this could be easily and safely obtained, and probably often is, with the glove and dynamometer. In the ring, as in many other instances in which all seems physical to the casual observer, moral elements enter. The dangerousness of the man whose exact moving energy of blow is known, is to a certain extent discounted, so potent is the imagination in the affairs of men. Professional fighters know, as well as every one else does, that everything unknown seems magnificent.

The element of quickness in a boxer, in addition to courage, skill, strength, weight, and endurance is indispensable. In the case of such men as Sandow, muscles have been trained by work so ponderous that they do not respond to the will for elastic, quick movements. Men like him cannot put the same speed into their blows as can men trained as Corbett has been, nor can they put the weight of their bodies as effectively into their blows as men can who have

been trained for strong, lithe movements. Consequently, the blows of such men, no matter how heavy the men are, have less power than those of men trained as boxers. So far from Sandow's being able in the ring with Corbett to break his arm or otherwise disable him, he would probably not hit Corbett a single blow, or if he did, not one that would have the effectiveness of his opponent's, because it would lack the speed and accompanying weight thrown into his by a boxer endowed with a rare combination of height, strength, weight, and reach, supplemented by agility marvelous for a large man, trained by life-practice to highest excellence within his sphere, and all crowned by the habits which promote endurance.

We should rejoice that we live in an age remote from the false sentiment of some former times, an age of revived physical culture, when it is possible to bestow undisguised admiration on physical excellence of any kind, in its sphere as fine as moral worth, of which it is in some subtle way even now partially emblematical, to become, mayhap, in the course of time, through more general observance of the laws of nature, wholly identified with it, and indivisible in attributes. Within our own time is observable a great advance in obedience to those laws. It should be evident that the almost universal admiration for physical development and prowess is not wholly derived from the combative quality of mankind, but has its root deeper in human nature, in the general interest in the health and welfare of the species. If, however, it be needed that the combative manifestation of nature be sustained on moral grounds, then is its defense easy. Inasmuch as the present stage of development is conditioned in almost every sphere of animal life on self-defense, self-preservation being still the first law of nature, all teachings which tend to suppress among men any resort to the *ultima ratio* of their kind, tend also to transform their means of defense exclusively into the meaner modes of securing it, into the adoption, to that inevitable end, of cunning and treachery, and the swarm of the meaner vices, sapping the noble elements of their nature, which must go hand and hand and stand or fall together. For my own part, I candidly avow that my observation of life from boyhood onward, derived from personal experience, from history, and from noting racial tendencies in the present era, has led me to believe that, with reprobation and repression of physical force, as potential, and therefore, if need arise, actual, in matter for which law offers no protection, nor ever will or can, must inevitably go various un-

derhandedness in the conduct of life. I firmly believe that those nations which cultivate physical development by countenancing and promoting athletic sports and contests, with due regard to the exclusion of the cowardliness of brutality, will ever possess in their citizens, as compared with those of other nations differently prompted through race, or differently controlled by law or dominant public sentiment, a greater proportion than the others of those inspired by independence of character, honor, and disposition to fairness as between man and man, constituting them relatively the more stalwart lovers and defenders of the right in every form.

Obituary Notice of George de Benneville Keim.

By D. G. Brinton, M.D.

(*Read before the American Philosophical Society, May 4, 1894.*)

Those who have had a reasonably long and intimate knowledge of men must have observed that among the individuals prominent in the active affairs of the day there are two classes—the one, of such as are wholly absorbed in their daily pursuits, whose natures are, to use a simile of Shakespeare's, "subdued to what they work in, like the dyer's hands"—the other, who, however compulsive and harassing their avocations, retain an individual and independent freshness of personality, often strangely in contrast with the requirements of their working hours.

Distinctly to the latter class belonged our late member, George de Benneville Keim; and all who enjoyed his friendship will agree that an appreciation of his career would be imperfect which failed to present these two aspects of his character. I shall begin with that in which he was familiar to the world in general, and then I shall say a few words about him, as he was known to his friends and near associates.

Mr. Keim was a descendant in the sixth generation of Johann Keim, a member of the Society of Friends, who emigrated from the Rhenish Palatinate to the colony of Penn, and settled at Oley, Berks county, in 1704. The grandson of this Quaker emigrant was General George de Benneville Keim, an officer of note in the